Claims

1. A line guide apparatus (10) for guiding lines, such as cables, hoses or the like, between a first and a second connection point (2, 3) movable relative to the first, in particular on a robot (1) with multiple degrees of freedom, comprising:
a plurality of links, which form an accommodation space for lines, are arranged successively in a longitudinal direction (L) and are connected together in articulated manner by a respective articulated connection, wherein the articulated connection allows three-dimensional deflection of the connected links relative to one another; and
at least one elastic return element (300);
characterized in that
the line guide apparatus has a variable-length portion (11), which comprises a number of links (200A, 200B; 700A, 700B) which are connected together so as to be relatively rotatable relative to one another about the longitudinal direction and longitudinally adjustable relative to one another for elongation of the variable-length portion (11) in the longitudinal direction (L),

and in that the return element (300) is elastically longitudinally expandable and is arranged in such a way that it exerts on the variable-length portion (11) a return force which counteracts elongation of the variable-length portion (11).

2. The line guide apparatus according to Claim 1, characterized in that the number of links (200A, 200B; 700A, 700B) of the variable-length portion (11) are articulately connected and/or are connected or couplable in such a way that longitudinal adjustment of two links (200A, 200B; 700A, 700B) relative to one another brings about relative rotation (R1, R2) thereof.

3. The line guide apparatus according to Claim 1, characterized in that the connection of in each case successive links (200A, 200B; 700A, 700B) of the variable-length portion (11) is configured such that longitudinal adjustment of two links relative to one another predetermines as a function of direction a relative rotation in the

one or the opposing direction of rotation about the longitudinal direction (L).

4. The line guide apparatus according to Claim 3, characterized in that the connection comprises a rotary guide, which, on elongating longitudinal adjustment of the two links (200A, 200B; 700A, 700B), brings about relative rotation thereof in a first direction of rotation (R1) and, on return longitudinal adjustment of the two links, brings about opposing relative rotation thereof.

5. The line guide apparatus according to one of the preceding claims, characterized in that the variable-length portion has a first sub-portion (11A), in which connected links (200A; 700A) in each case rotate in relative manner on elongation in a first direction of rotation (R1), and a second sub-portion (11B), in which connected links (200B; 700B) rotate in relative manner on elongation in a second direction of rotation (R2), which is the opposite direction to the first direction of rotation.

6. The line guide apparatus according to one of the preceding claims, characterized in that
- the at least one return element (300) is arranged to exert pretensioning in the longitudinal direction, which pretensioning contracts the variable-length portion; and/or
- the at least one elastic return element (300) is embodied as a rope or band, wherein the return element in particular comprises or is a rubber cable, preferably with rubber threads and/or rubber bands and a braided cover.

7. The line guide apparatus according to Claim 6, characterized in that an adjusting device (302; 927) for adjusting the pretensioning of the return element (300) is provided at at least one end region of the variable-length portion (11), in particular at an end link (200; 900) of the variable-length portion.

8. The line guide apparatus according to Claim 5, characterized in that a middle piece (250; 800) is provided between two sub-portions (11A, 11B) of the variable-length portion, wherein the middle piece (250; 800) has strain relief (840) for lines (60) to be guided

and/or preferably has a greater structural length than the structural length or pitch of the number of links of the variable-length portion (11), and/or wherein the middle piece (250; 800) is connected in particular at each of its longitudinal ends in each case with one of the sub-portions (11A, 11B) rotatable in opposing directions, in particular via respectively opposing rotary guides (730A, 730B).

9. The line guide apparatus according to one of the preceding claims 1 to 8, characterized in that at least the links (200A, 200B; 700A, 700B) of the variable-length portion (11) in each case have a central core (210; 710) with a central passage opening (225; 725) through which the elastic return element (300) is passed; and/or the core (210; 710), on longitudinal adjustment of two links relative to one another, predetermines as a function of direction a relative rotation in the one or the opposing direction of rotation about the longitudinal direction.

10. The line guide apparatus according to claim 4, characterized in that at least the links (200A, 200B; 700A, 700B) of the variable-length portion (11) in each case have a central core (210; 710) with a central passage opening (225; 725) through which the elastic return element (300) is passed, wherein the core (210; 710) has guide elements (220, 230; 720, 730) of the rotary guide.

11. The line guide apparatus according to one of the preceding claims, characterized in that at least the links (200A, 200B; 700A, 700B) of the variable-length portion (11) in each case have a central core (210; 710), which forms a joint head (220; 720) and a joint receptacle (230; 730A, 730B) opposite in the longitudinal direction, which latter is matchingly configured for articulated connection with the joint head of the next link, wherein joint head and joint receptacle preferably form the rotary guide for predetermining the relative rotation, in particular by one or more helically running guide faces (232) on the inside of the joint receptacle (230; 730A, 730B), which interact to predetermine the relative rotation with one or more guide elements on the joint head (220; 720).

12. The line guide apparatus according to Claim 11, characterized in that
- the joint head (220; 720) has a basic shape with a substantially triangular cross-section, preferably with arcuately rounded sides (221), whose three vertices (222) are guided as guide elements against corresponding helically running guide faces (232) on the inside of the joint receptacle (230A, 230B; 730A, 730B); or
- the joint head (120) has a basic shape with a substantially elliptical cross-section, whose two major vertices are guided as guide elements against corresponding helically running guide faces on the inside of the joint receptacle (130); **and/or**
- joint head and joint receptacle (220, 230; 720, 730) form an articulated connection which is longitudinally adjustable, relatively rotatable and, for three-dimensional mutual deflection of the connected links, swivelable about at least two axes perpendicular to the longitudinal direction, wherein in particular the sides of the basic shape of the joint head are concavely shaped in the longitudinal section, in particular corresponding to a radius of curvature for three-dimensional deflectability.

13. The line guide apparatus according to Claim 11 or 12, characterized in that
- the central core (710), at least the joint receptacle, is formed by two separate components (710A, 710B) which are connectable to one another; or
- the joint receptacle (1230A, 1230B) is formed by at least two separate insert parts (1250A, 1250B), which are attached to the core in a receptacle, wherein each insert part preferably in each case has a helically running inner surface (232).

14. The line guide apparatus according to one of the preceding claims, characterized in that at least the links (700A, 700B) of the variable-length portion (11) or all links in each case have a central core with at least two substantially radial webs (72) by way of which in each case at least one shell segment is retained, to delimit the accommodation space in the radial direction, wherein the shell segments (72) are preferably arranged in upwardly pivotable

manner and/or are of flexible construction and form an insertion opening (71A, 71B) between two shell segments (71).

15. The line guide apparatus according to Claim 14, characterized in that, at least in the variable-length portion (11), the shell segments (201; 1201) form a circumferentially and longitudinally closed tube, wherein the connection of respectively successive links comprises a rotary guide (1320, 1330) at the shell segments.

16. The line guide apparatus according to one of the preceding claims, characterized in that the connection longitudinally adjustable in the longitudinal direction in each case comprises at least two longitudinal stops, which restrict the longitudinal adjustment of two links in both directions, wherein the longitudinal stops (733) are formed on the core (710) and/or on shell segments, wherein preferably both longitudinal stops are formed by a joint receptacle (730A, 730B) on the core (710).

17. The line guide apparatus according to Claim 16, characterized in that the longitudinal play of the longitudinally adjustable connection amounts to at least 20%, preferably to at least 30% and in particular up to 45% of the link pitch or axial structural length of the link (200A, 200B; 700A, 700B), in particular of the central core.

18. The line guide apparatus according to one of the preceding claims, further comprising at least one line (60) guided in the line guide apparatus (10)), characterized in that the at least one line is arranged to run helicoidally or helically in the variable-length portion, in particular corresponding to a first helix coil (S1; 61A) in the first sub-portion (11A) and a second helix coil (S2; 61B) in the second sub-portion (11B) running with an opposing direction of rotation.

19. A robot (1), in particular an industrial articulated-arm robot, characterized by a line guide apparatus (10) according to one of preceding claims 1 to 18.